CLAIMS

What is claimed is:

1. A method for processing an image using a bilateral filter, comprising the steps of:

generating a modified bilateral filter by reformulating an initial bilateral filter for each pixel location in the image into a sum of the original signal value of a central pixel at said pixel location and a bilateral correction term which is a function of local signal differences between the central pixel and its neighbors; and

processing the image using the modified bilateral filter to generate a filtered output.

2. The method of claim 1, further comprising the steps of:

processing each pixel (i) in the image by:

buffering a neighborhood of said pixels as determined by the size of the bilateral filter convolution kernel Kj; and

calculating a filtered value for said pixel (i) using a bilateral filter including a normalization expression implemented as a Taylor series expansion.

3. The method of claim 2, wherein said Taylor series expansion is implemented as a truncated infinite geometric sum.

4. The method of claim 2, wherein said Taylor series is implemented using an order of expansion of zero.

5. The method of claim 2, wherein the Taylor series is expanded as a truncated infinite product.

6. The method of claim 2, wherein said truncated infinite geometric sum having an order of expansion of one is used to implement a signal processing device operating in accordance with said method.

7. The method of claim 6, wherein said signal processing device comprises a processor executing a set of computer-readable instructions.

8. The method of claim 2, including the additional steps of:

replacing the normalization expression with a value of 1;

for each possible quantized said signal difference:

pre-calculating the product of the photometric weight for each neighboring pixel j and the signal difference Δf_j between pixel j and center pixel i, to produce a signal value PSI(Δf_j) representing the influence of neighboring pixel j;

storing each said value of PSI in a look-up table; and

using a value of PSI in the look-up table corresponding to an instant value of Δf_j to calculate the contribution of the neighboring pixel j, by multiplying the value for pixel j with a corresponding convolution kernel coefficient K_j.

9. The method of claim 2, wherein the normalization expression is expanded by performing the additional steps of:

for each possible quantized said signal difference Δf_j:

pre-calculating the photometric weight $g(\Delta f_j)$;

storing each said value of photometric weight in a look-up table; and

using a value of g in the look-up table corresponding to an instant value of a signal difference in one or more color-channels Δf_j to compute the bilateral weight of a neighboring pixel j, by multiplying the value for pixel j with a corresponding convolution kernel coefficient K_j;

computing a bilateral correction term for each of the color channels, by multiplying the calculated bilateral weight of the

neighboring pixel j with the signal differences Δc_j corresponding to each of the color channels; and

adding each of the computed bilateral correction terms to the central pixel value for the corresponding channel.

10. A method for generating a zero-order approximation of a bilateral filter, wherein a single channel input signal including an image comprising a plurality of pixels is filtered to provide a single channel output corresponding to one dimension of a filtered image, the method comprising the steps of:

summing, for all said pixels i in the image, contributions from each neighboring pixel j, corresponding to K_j, wherein the contribution of each said neighboring pixel j is:

(a) the photometric weight for each said neighboring pixel j, multiplied by

(b) the signal difference between pixel j and the center pixel single channel signal; multiplied by

(c) the convolution kernel coefficient K_j for the neighboring pixel (j); and

adding the single channel center pixel signal to generate the single channel output for the center pixel;

wherein said photometric weight for neighboring pixel j is determined by the difference between the center pixel signal and the signal at the neighboring pixel j, corresponding to K_j; and

wherein the convolution kernel coefficient K_j is a weight that determines the contribution of neighbor j to a weighted average filter.

11. The method of claim 10, including the steps of:

quantizing the input signal;

for each possible quantized said signal difference:

pre-calculating the product of the photometric weight for each neighboring pixel j and the signal difference Δf_j between pixel j and center pixel i, to produce a signal value PSI(Δf_j) representing the influence of neighboring pixel j;

storing each said value of PSI in a look-up table; and

using the value of PSI in the look-up table corresponding to an instant value of Δf_j to calculate the contribution of the neighboring pixel j, by multiplying the value for pixel j with a corresponding convolution kernel coefficient K_j.

12. The method of claim 11, wherein each of the steps therein is performed for a second single channel input to generate the filtered image.

13. A system for processing an image including a plurality of pixels comprising:

a processor and associated memory;

a bilateral filter program, stored in said memory and executable by said processor;

wherein the bilateral filter program processes each pixel (i) in the image by:

reformulating the bilateral filter, for each pixel location in the image, into a sum of the original signal value of a central pixel at said pixel location and a bilateral correction term which is a function of local signal differences between the central pixel and its neighbors;

buffering a neighborhood of said pixels as determined by the size of the bilateral filter convolution kernel Kj; and

calculating a filtered value for said pixel (i) using a bilateral filter including a normalization expression implemented as a truncated Taylor series expansion.

14. The system of claim 13, wherein said truncated Taylor series expansion is implemented by a truncated infinite geometric sum.

15. The system of claim 13, wherein said Taylor series is implemented using an order of expansion of zero.

16. The system of claim 13, wherein said Taylor series is expanded as a truncated infinite product.

17. The system of claim 16, wherein said truncated infinite product is implemented using a power series.

18. The system of claim 13, wherein said image is captured and processed by a digital camera.

19. The system of claim 13, including a look-up table stored in said memory, wherein the normalization expression is expanded using a Taylor series expansion by performing the additional steps of:

for each possible quantized said signal difference:

pre-calculating the product of the photometric weight for each neighboring pixel j and the signal difference Δf_j between pixel j and center pixel i, to produce a signal value $PSI(\Delta f_j)$ representing the influence of neighboring pixel j;

storing each said value of PSI in the look-up table; and

using a value of PSI in the look-up table corresponding to an instant value of Δf_j to calculate the contribution of the neighboring pixel j, by multiplying the value for pixel j with a corresponding convolution kernel coefficient K_j.

20. The system of claim 13, including a bit-shift register, wherein the normalization expression is implemented using the bit-shift register.

21. A method for generating a division-free bilateral filter for processing an input signal comprising the steps of:

formulating an initial bilateral filter including a normalization expression containing a division operation;

reformulating the initial bilateral filter, at each pixel location in the image, into an intermediate bilateral filter comprising a sum of the original signal value of a central pixel at said pixel location and a bilateral correction term which is a function of local signal differences between the central pixel and its neighbors;

expanding the normalization expression as a truncated infinite geometric sum;

re-formulating the intermediate bilateral filter as said division-free bilateral filter by replacing the normalization expression with the truncated infinite geometric sum; and

processing the input signal using the division-free bilateral filter to generate a filtered output signal.

22. The method of claim 21, wherein said truncated infinite geometric sum is implemented by a Taylor series expansion.

23. The method of claim 21, wherein the normalization expression is expanded as a truncated infinite product.

24. The method of claim 23, wherein said truncated infinite product is implemented using a power series.

25. A method for processing an image using a bilateral filter, comprising the steps of:

reformulating the bilateral filter, at each pixel location in the image, into a sum of the original signal value of a central pixel at said pixel location and a bilateral correction term which is a function of local signal differences between the central pixel and its neighbors; and

processing each pixel (i) in the image by:

buffering a neighborhood of said pixels as determined by the size of the bilateral filter convolution kernel Kj; and

calculating a filtered value for said pixel (i) using a bilateral filter including a normalization expression implemented as a Taylor series expansion.

26. A system for processing each pixel (i) in an image including a plurality of pixels comprising:

means for buffering a neighborhood of said pixels as determined by the size of the bilateral filter convolution kernel Kj; and

means for calculating a filtered value for said pixel (i) using a bilateral filter including a normalization expression implemented as a truncated Taylor series expansion.

27. The system of claim 26, wherein said Taylor series expansion is implemented by a infinite geometric sum.

28. The system of claim 26, wherein said Taylor series expansion is implemented using an order of expansion of zero.

29. The system of claim 26, wherein the normalization expression is expanded as a truncated infinite product.

30. A software product comprising instructions, stored on computer-readable media, wherein the instructions, when executed by a computer, perform steps for processing an image including a plurality of pixels, comprising:

reformulating a bilateral filter, at each pixel location in the image, into a sum of the original signal value of a central pixel at said pixel location and a bilateral correction term which is a function of local signal differences between the central pixel and its neighbors; and

processing each pixel (i) in the image by:

buffering a neighborhood of said pixels as determined by the size of the bilateral filter convolution kernel Kj; and

calculating a filtered value for said pixel (i) using a bilateral filter including a normalization expression implemented as a Taylor series expansion.